ELECTRICAL INSTRUMENTS. By R. L. SMITH-ROSE, D.Sc., Ph.D., A.M.I.E.E. and R. S. J. SPILSBURY, B.Sc., M.I.E.E.

The majority of the wireless apparatus in this year's exhibition which could have any claim to distinct novelty comprised sources of radio- and audio-frequency voltages, and the components required for use with these in carrying out various types of high-frequency alternating current measurements. Many of the stands contained specimens representing the usual equipment of a radio-frequency laboratory, but in general these differed only in detailed improvement from the corresponding exhibits in previous years.

In the field under review, Messrs E. K. Cole, Ltd., represent newcomers to the exhibition, and this firm showed and demonstrated some measuring apparatus of use in the testing of radio receivers during and after manufacture. The first exhibit consisted of a master signal generator, which supplies modulated alternating current at five radio-frequencies, suitable for the carrying out of sensitivity, selectivity and frequency tests over the range covered by the normal broadcast receivers. A suitable screened attenuator and dummy aerial are supplied for controlling the input to the receiver, while a simple A.C. voltmeter is employed to measure the output. Other exhibits by this firm included an audio-frequency capacity bridge for the checking and balancing of receiving condensers on a manufacturing scale, and a simple portable oscillator giving a modulated radio-frequency supply for the service testing of wireless receivers.

On the neighbouring stand of Messrs Claude Lyons, Ltd., were shown a few components which were typical of the large range of apparatus supplied by this firm for use in the radio laboratory. The first item noted was a self-contained beat-frequency oscillator giving an audio-frequency supply over the range 5–10,000 cycles per second. The maximum power output in a load resistance of 5000 ohms is about 10 milliwatts and over the range quoted the harmonic content is low and there is no

difficulty in keeping the output constant as required for certain measurement purposes. A laboratory type of signal generator was also shown, this being capable of giving modulated radio-frequency supplies over a wide range of radio-frequencies, and with varying output and modulation percentage. A feature of this and the previous instrument was the use of a variable condenser with a 300° scale, which with the aid of a lens can easily be read to one-tenth of a degree. A simple direct-reading absorption wave-meter having an accuracy of better than 1 per cent. over its range of 16–600 metres, was fitted with a similar type of condenser, the scales in this case being ingeniously attached to their corresponding plug-in inductance coils.

The STANDARD TELEPHONES & CABLES, LTD., exhibited two types of audio-frequency oscillator, suitable both for laboratory work and the routine testing of communication equipment. The first of these was a beat-tone oscillator having a frequency range of 20–12,000 cycles per second, and an output of about 240 milliwatts in a 600-ohm resistor. The other set was a straightforward audio-frequency oscillator calibrated over the range 20–20,000 cycles per second, and giving an output of about 300 milliwatts. In this case the oscillator was combined with a suitable attenuator and output meters as a self-contained testing equipment. A capacity and conductance bridge having an extensive range for audio-frequency capacity and power-factor measurements on cables and associated apparatus was also exhibited by this firm.

The design of beat-tone oscillator previously developed by the National Physical Laboratory has been adopted by Messrs MUIRHEAD & CO., LTD., who exhibited two forms of the instrument. The first is suitable for laboratory table use, while in the second the arrangement has been modified to the form of rack mounting now so largely employed in connexion with communication engineering work. This oscillator provides a continuously variable source of alternating current over a range of from 10 to 10,000 cycles per second. The maximum power output over this range for an output resistance of 5000 ohms varies from 500 to 1000 milliwatts and the total harmonic content is less than 2 per cent. at all frequencies. Messrs MUIRHEAD & CO., LTD., also exhibited equipment designed in co-operation with the British Broadcasting Corporation for controlling the frequency of broadcasting stations by means of a tuning-fork of the temperature- and pressure-regulated type developed at the National Physical Laboratory.

The stand of Messrs H. W. SULLIVAN, LTD., displayed the usual wide range of precision and standard apparatus for radio-frequency measurements. Among the new items was shown a dynatron oscillating wavemeter, stated to have an accuracy of 1 part in 10,000 over the wave-length range 30–10,000 metres. Other useful instruments included a simple absorption wavemeter, for the range 10–100 metres with an accuracy better than 0·5 per cent., a stable oscillation generator and a heterodyne wavemeter for the short-wave band below 100 metres.

Among the exhibits of Messrs MARCONI'S WIRELESS TELEGRAPH CO., LTD., was to be seen a multi-stage valve amplifying equipment having a uniform gain of about 100 decibels over the unusually wide frequency range of 10–150,000 cycles per second. This set employs screen-grid valves with resistance-capacity coupling and has been specially developed for use with photoelectric cells for television and other purposes. Apparatus was also shown for the reception in aircraft and visual indication of signals from a wireless beacon of the equi-signal zone course-indicating type. This system for the navigation of aircraft by wireless has been widely developed in America and is now being adopted to some extent in this country.

Turning to lower frequencies, one of the most interesting indicating instruments was a small power wattmeter, designed by Dr Mallett and shown by Messrs H. TINSLEY & CO. In this device two triodes are employed, one of which has applied to its grid the sum of two voltages, one proportional to the voltage across the load and the other proportional to the current in the load, while the grid of the other receives the difference of these two voltages. Under suitable conditions the difference between the D.C. anode currents of the two triodes then gives the power in the load, and this power can be indicated by a moving-coil galvanometer. The instrument can be made to give its full indication for a milliwatt or less, and is applicable to telephonic frequencies. Among indicating instruments in general no great novelty of principle was discernible. A tendency to size reduction was evident, particularly in the series of 2½ in. dial induction wattmeters, ammeters, voltmeters, and power-factor indicators shown by Messrs NALDER BROS. & THOMPSON, LTD.: these are intended primarily for miniature switchboards, and are claimed to give B.S. 1st grade accuracy. Messrs FERRANTI, LTD., showed a 2½ in. dial electrostatic voltmeter for 50–300 volts which should have many applications: the damping brings the pointer to rest in about 10 sec. On the same stand was a miniature A.C. test set consisting of a six-range voltmeter and a two-range ammeter, which latter instruments can be used with a special current transformer. The price of this set is moderate, and

B.S. 1st grade accuracy is claimed. The CAMBRIDGE INSTRUMENT CO., LTD., showed a low-reading millivoltmeter of the metal-rectifier type giving full-scale deflection for 30 millivolts: the operating current is less than 1 milliampere, and the scale shape is good: it is of course subject to the usual wave-form error. The sizes and prices of magneto-ohmmeters have been further reduced, very small instruments being shown by the RECORD ELECTRICAL CO., LTD., and Messrs EVERSHED & VIGNOLES, Ltd.: the former instrument is slightly the heavier (weight $3\frac{3}{4}$ lb.), but the driving handle is rather more conveniently arranged. Messrs EVERSHED & VIGNOLES, LTD., also showed a small combined insulation and continuity tester, with magneto operation, while THE RECORD ELECTRICAL CO., LTD., exhibited a continuity tester embodying an alkaline battery, and arranged to supply a substantial current to the circuit. An innovation due to the SALFORD ELECTRICAL INSTRUMENTS, LTD., was the use of a transformer and rectifier as the source of supply for an ohmmeter, the instrument being self-contained.

Further advance in instrument current transformers is not at present needed where cost is not a decisive factor, and the tendency is to seek economy and convenience in instruments on the lines of the "Multiversal" transformer shown by Messrs ELLIOTT BROS. (LONDON), LTD. By means of three secondary tappings in conjunction with various fixed and movable primary windings 28 ratios are obtained from one instrument, though the advantage of a single set of corrections is sacrificed. The phase angle at 7·5 VA., 1/10th load, and 50 cycles, is about 10 min. under the worst condition.

A useful instrument also shown by Messrs ELLIOTT BROS. (LONDON), LTD., is the Shotter power-factor finder. This consists of a small ironclad wattmeter, the stator winding of which is connected in series with the load: the rotor carries two opposing windings, one of which is in series with a condenser, and the other with a resistance. By means of a potentiometer a fraction of the circuit voltage is applied to one of these two circuits, and the remainder of the voltage is applied to the other. By suitable adjustment of the potentiometer, depending on the power factor of the circuit, the effective ampere-turns on the rotor may be brought to quadrature with the stator flux, when the wattmeter needle rests on a fiducial mark. Hence the turning head of the potentiometer can be calibrated in circuit power factor. An excellent point is that the polarities of both the current and voltage terminals are immaterial. Mr Shotter is also responsible for the rectifier kVA recorder shown on this stand: details of the method by which the difficulties due to the ripples on the rectified currents are overcome cannot at present be disclosed.

An improved type of recording (graphic) instrument was shown by Messrs EVERETT, EDGCUMBE & CO., LTD. This instrument is operated by a metal rectifier, and this has enabled a very large torque to be provided, with a low moment of inertia, giving a very rapid travel of the pen. The modification has been applied to the type of instrument in which the occurrence of a circuit fault causes the paper speed to be greatly increased, in order to secure a clear record of the disturbance: when the fault is cleared the paper speed reverts to normal, and the hour scale is not upset. On the same stand was a voltmeter in which, in addition to the normal swamp resistance, several circuits tuned to harmonics of the fundamental frequency are provided. By operating a change-over switch the voltages due to the corresponding harmonics can be indicated. A further instrument shown by Messrs EVERETT, EDGCUMBE & CO., LTD., is a milliampere-second meter operating on the ampere-hour meter principle, instead of on the usual ballistic system: this method of operation has the advantage that the pointer remains nearly stationary after its throw, instead of drifting back at once towards zero.

On the stand of Messrs CROMPTON PARKINSON, LTD., was a thermal type of maximum demand indicator, of robust construction. In this instrument two bi-metallic strips are provided, one only of which is heated by the current measured, and a pointer is operated by the difference between the travel of the two strips. The instrument should thus be independent of variations of air temperature, but its interpretation of the "maximum demand" is of course somewhat arbitrary.

Messrs H. W. SULLIVAN, LTD., exhibited a Schering Bridge designed especially to allow accurate work to be done by unskilled operators. An innovation is the use of a visual balance indicator as an alternative to the usual telephones.

Finally mention may be made of the "invertor" shown by the EDISON SWAN ELECTRIC CO., LTD. This consisted of two grid-controlled mercury vapour discharge tubes, so connected that an alternating current could be obtained from a direct current: the frequency of alternation was approximately fixed by a condenser-resistance combination in the circuit. At present the power which can be dealt with is very small from the point of view of the engineer, but it is impossible to avoid wondering whether this device may not be the forerunner of invertors capable of dealing with thousands of kilowatts: such a development might have far-reaching effects on methods of energy transmission.